Application Note: 41621

Ferrous Base

ARL ADVANT'X Series IntelliPower™ 2500 Sequential X-Ray Fluorescence Spectrometer

Key Words

- ARL ADVANT'X
- IntelliPower™
- Ferrous Base
- X-Ray Fluorescence
- XRF

Irons

There are several kinds of irons which are distinguished by their composition and use. They belong to two main categories:

- Pig irons (hot metal), forming the basic production for the manufacture of steel
- Cast irons, used for the production of semi-manufactured products

From a metallographic point of view, a distinction can be made between white cast iron with a cementite structure and grey cast iron which contains free graphite either in the form of laminae or nodules. These make grey cast iron inhomogeneous and therefore difficult to analyze. Alloy cast irons also exist where alloying elements such as nickel, chromium, manganese, copper, etc. are added to improve hardness, corrosion resistance or engineering properties.

Low alloy steels

This category covers steels which are destined for a wide variety of uses, such as the production of:

- Steel castings, rails, axles, boiler and ships plates, automobile bodies
- Girders, all kinds of bridge and structural sections
- Wires, nuts, bolts and forgings of almost any description
- Springs, cutting steels

From a compositional point of view, these steels can be distinguished by the fact that the alloying elements generally total less than 5-7 %. Typically, the main alloying elements are present at less than the following concentrations:
Mn 2 %; Cr 3 %; Ni 5 %; Cu 1.5 %; Mo 1.5 %; V 1 %.

High alloy steels

High alloy steels contain, in addition to iron and carbon, notable quantities of one or more of the following elements : nickel, chromium, manganese, silicon, cobalt, tungsten, molybdenum and vanadium. Included under this heading are:

- Stainless steels of types such as 18/8, austenitic, maraging, martensitic and all types of special stainless steels
- Tool steels
- High speed steels
- High manganese steels

Instrument parameters

The Thermo Scientific ARL ADVANT'X IntelliPower™ 2500 XRF spectrometer can be calibrated using commercially available standards or well analyzed samples from the user. It should be stressed that an XRF spectrometer is a very accurate comparator, but the accuracy of the final analysis is entirely dependent on the quality of the standards used for calibration.

Typical performance

ELEMENT	*CRYSTAL*	CONCENTRATION %	PRECISION (1 SIGMA) %		LOD ppm (3 SIGMA)
	Counting time		15 s.	60 s.	100 s.
Al	Aluminum	0.01	0.0004	0.0002	2.6
		0.10	0.0012	0.0006	
		1.00	0.0032	0.0016	
Ca	Calcium	0.10	0.0006	0.0003	1.3
C	Carbon	0.50	0.04	0.02	89
		1.00	0.06	0.03	
		2.00	0.1	0.05	
Ce	Cerium	0.10	0.0024	0.0012	4
Cr	Chromium	0.05	0.001	0.0005	2
		0.50	0.002	0.001	
		1.00	0.0028	0.0014	
		5.00	0.0064	0.0032	
		20.00	0.013	0.0064	
		30.00	0.016	0.008	
Cu	Copper	0.05	0.0012	0.0006	2.2
		0.50	0.004	0.002	
		1.00	0.0052	0.0026	
Bi	Bismuth	0.01	0.0008	0.0004	4.2
Mg	Magnesium	0.10	0.004	0.002	19
		1.00	0.01	0.005	
Mn	Manganese	0.05	0.001	0.0005	2.3
		0.50	0.0024	0.0012	
		1.00	0.0032	0.0016	
		2.00	0.0048	0.0024	
		10.00	0.011	0.0056	
Mo	Molybdenum	0.05	0.008	0.0004	1.2
		0.50	0.0022	0.0011	
		1.0	0.0032	0.0016	
		3.00	0.0064	0.0032	
		10.00	0.01	0.005	

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The values listed in the general table are calculated using the following formulae :

$$\text{Precision (1 sigma)} = \sqrt{\frac{P + BEC}{Q\,T}}$$

and

$$\text{LOD = limit of detection} = 3\sqrt{\frac{BEC}{Q\,T}}$$

where

- Q =counts per second per 1 % element
- BEC = background equivalent concentration
- T = time of analysis in seconds
- P = the percentage concentration at which the sigma value is calculated.

The limits of detection are determined with low alloy steels, except for carbon where cast irons are used. In practice, these values should agree with values measured practically using the mathematical derivation of standard deviation (1sigma).

$$1\text{sigma} = \pm\sqrt{\frac{\sum(X-\overline{X})^2}{n-1}}$$

where:

- X = the individual readings
- $\overline{X}$ = the arithmetic mean of the individual values
- n = number of determination (normally ≥ 10)

For guaranteed values, the values of precision and LODs should be multiplied by factor 2.

ELEMENT	*CRYSTAL*	CONCENTRATION %	PRECISION (1 SIGMA) %		LOD (3 SIGMA) ppm
	Counting time		15 s.	60 s.	100 s.
Nb	Niobium	0.01	0.0004	0.0002	1.3
		0.05	0.0004	0.0002	
		1.00	0.0016	0.0008	
Ni	Nickel	0.05	0.0014	0.0007	1.8
		0.50	0.0048	0.0024	
		1.00	0.0064	0.0032	
		10.00	0.02	0.01	
		20.00	0.026	0.013	
P	Phosphorus	0.01	0.0004	0.0002	1.1
		0.05	0.0008	0.0004	
	Ge 111	0.10	0.0012	0.0006	
Pb	Lead	0.01	0.001	0.0005	5.6
S	*Sulphur	0.01	0.0002	0.0001	1
	*=low % Mo	0.5	0.0004	0.0002	
	samples	0.30	0.001	0.0005	
Sb	Antimony	0.01	0.0008	0.0004	11
		0.05	0.001	0.0005	
Sn	Tin	0.01	0.0006	0.0003	9.2
		0.05	0.0008	0.0004	
Si	Silicon	0.05	0.018	0.009	3.5
		0.50	0.0048	0.0024	
		1.00	0.0066	0.0033	
	PET	2.00	0.009	0.0046	
Ta	Tantalum	0.10	0.0028	0.0014	6.8
		1.00	0.008	0.004	
Te	Tellurium	0.10	0.0026	0.0013	8.8
Ti	Titanium	0.01	0.0004	0.0002	1.3
		0.10	0.0008	0.0004	
V	Vanadium	0.05	0.0008	0.0004	1
		0.50	0.002	0.001	
		1.00	0.0032	0.0016	
		5.00	0.008	0.004	
W	Tungsten	0.05	0.0016	0.0008	4.8
		0.50	0.005	0.0024	
		1.00	0.0064	0.0032	
		10.00	0.02	0.01	
		25.00	0.032	0.016	
Zn	Zinc	0.01	0.0004	0.0002	2.2
Zr	Zirconium	0.01	0.0004	0.0002	1.3
		0.05	0.0004	0.0002	

Conclusion

It is seen that analysis of irons and steels can be performed with ease using the mid-power sequential XRF spectrometer ARL ADVANT'X IntelliPower™ 2500. Precision levels are excellent even at shorter counting time.

Thanks to a clever management of power, this spectrometer can operate up to 2500W without requiring external water cooling. Therefore neither tap water, nor a water cooler is required.

Furthermore, operation is made easy through the new state-of-the-art OXSAS software under MS-Windows® XP Professional.

In addition to these offices, Thermo Fisher Scientific maintains a network of representative organizations throughout the world.

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